IRI Symposium on Changing Paradigms in Science and Technology Policy

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THE OLD PARADIGM

Vannevar Bush model: Scientific research intrinsically valuable; can—and should—absorb all available resources.

Historical context:

- **The Economy**: Post-war recovery; re-tooling of the military-industrial base; mass production manufacturing
- **Science and Technology**: Revolutionary impact of science on national security; pre-eminence of physical sciences; government R&D predominates
- **Geopolitics**: Managing the military balance of power; defense technologies critical

CHANGING PARADIGMS

No consensus; no apparent model for technology policy.

Fundamentally different context for science and technology policy:

- **The Economy**: Relatively stable growth; globalization; transition to a knowledge-based economy
- **Science and Technology**: Rapid change; multidisciplinary science and technology at forefront; industry R&D predominates
- **Geopolitics**: Post Cold War stability; technological and economic competition in a global era

TRANSITION TO A KNOWLEGE-BASED ECONOMY

Shift in output and distribution of R&D from manufacturing to non-manufacturing sectors…

	1970	1980	1990	1996
Composition of output (percent of GDP by industry group)	Mfg.: 24.1% Services: 11.6% FIRE: 14.1%	Mfg.: 21.0% Services: 13.6% FIRE: 15.0%	Mfg.: 18.0% Services: 18.4% FIRE: 17.8%	Mfg.: 17.4% Services: 20.2% FIRE:19.0%
Distribution of R&D (percent of total industry R&D)	Mfg.: 97.8 Non-mfg.: 2.2	Mfg.: 96.6 Non-mfg.: 3.4	Mfg.: 80.0 Non-mfg.: 20.0	Mfg.:75.0 Non-mfg.:25.0

Sources: BEA, NSF. “FIRE” = finance, insurance, and real estate.

…and increasing interdependence between product and service functions within many manufacturing firms.

TRANSITION TO A KNOWLEGE-BASED ECONOMY

Rapid expansion of investment in information technology equipment.

	1970	1980	1990	1997
Investment in Information Processing Equipment (share of total fixed producers durable equipment)	$10.7 billion (7%)	$45.4 billion (17%)	$116.2 billion (30%)	$305.2 billion (46%)

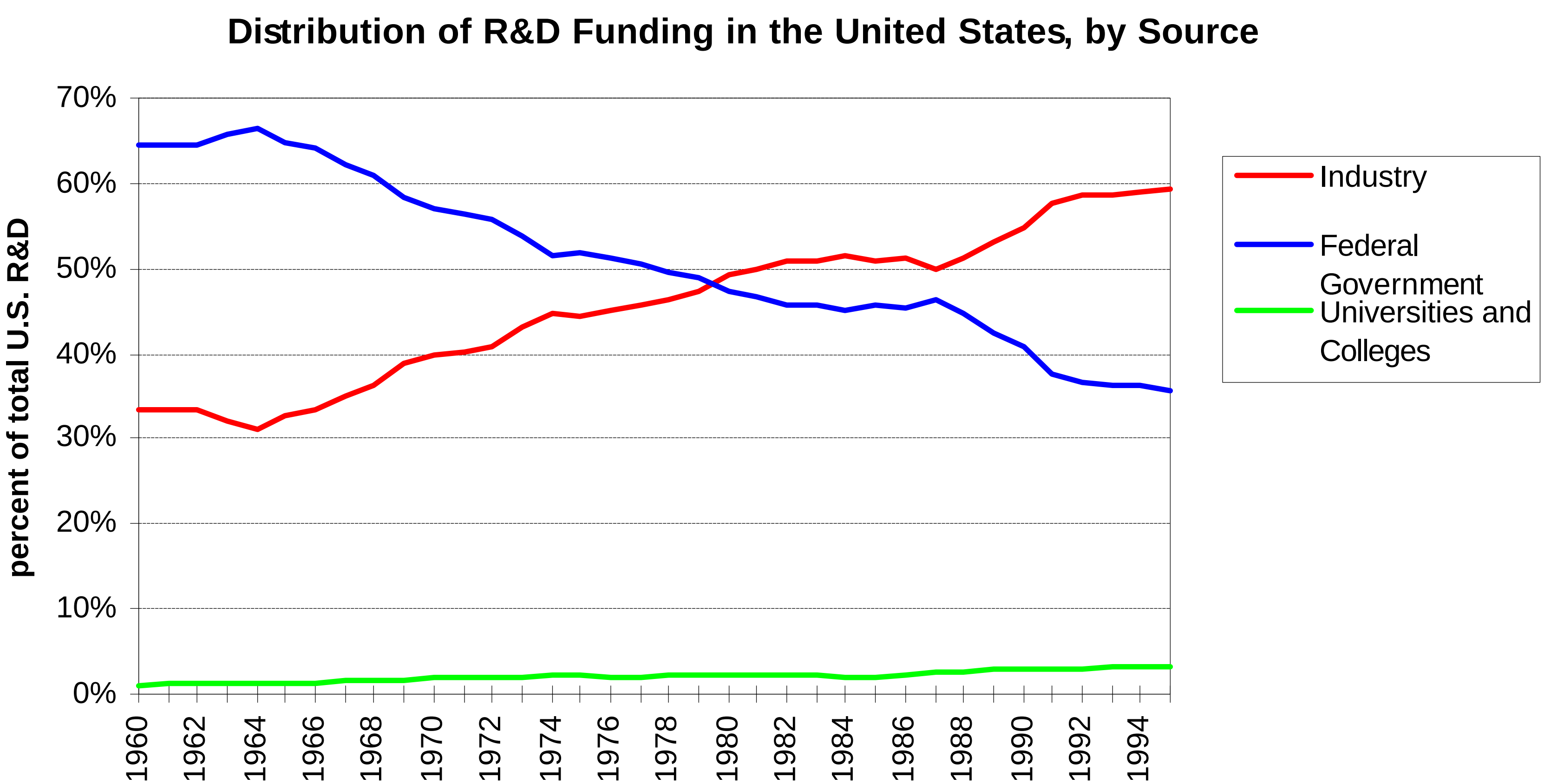
Sources: BEA. Data expressed in constant 1992 dollars.

The total cost of using IT in service firms is about five times the level of expenditures on IT equipment. Key role for assimilation/utilization practices.
Changing industry needs:

- **Generic technologies** (controlling large networks, distributed databases, data management, systems management and integration)
- **Improved infrastructure capacity and services** (conformance testing for standards, next-generation Internet protocols, quality of service measurement tools)

TRANSITION FROM GOVERNMENT TO INDUSTRIAL R&D

Tremendous change in the sources of R&D funding.



RESTRUCTURING OF INDUSTRIAL R&D

Industry R&D spending has been growing strongly. But competition, restructuring have changed the composition of R&D.

- Shorter time horizons: Spending on "directed basic research" growing more slowly than total industry R&D
- Restructuring or elimination of central labs; R&D increasingly centered on business units
- Relatively high hurdle rates for R&D investments

An effective business strategy. But suggests **under-investment in next-generation technologies**.

A COMPLEX, RAPIDLY CHANGING S&T ENTERPRISE

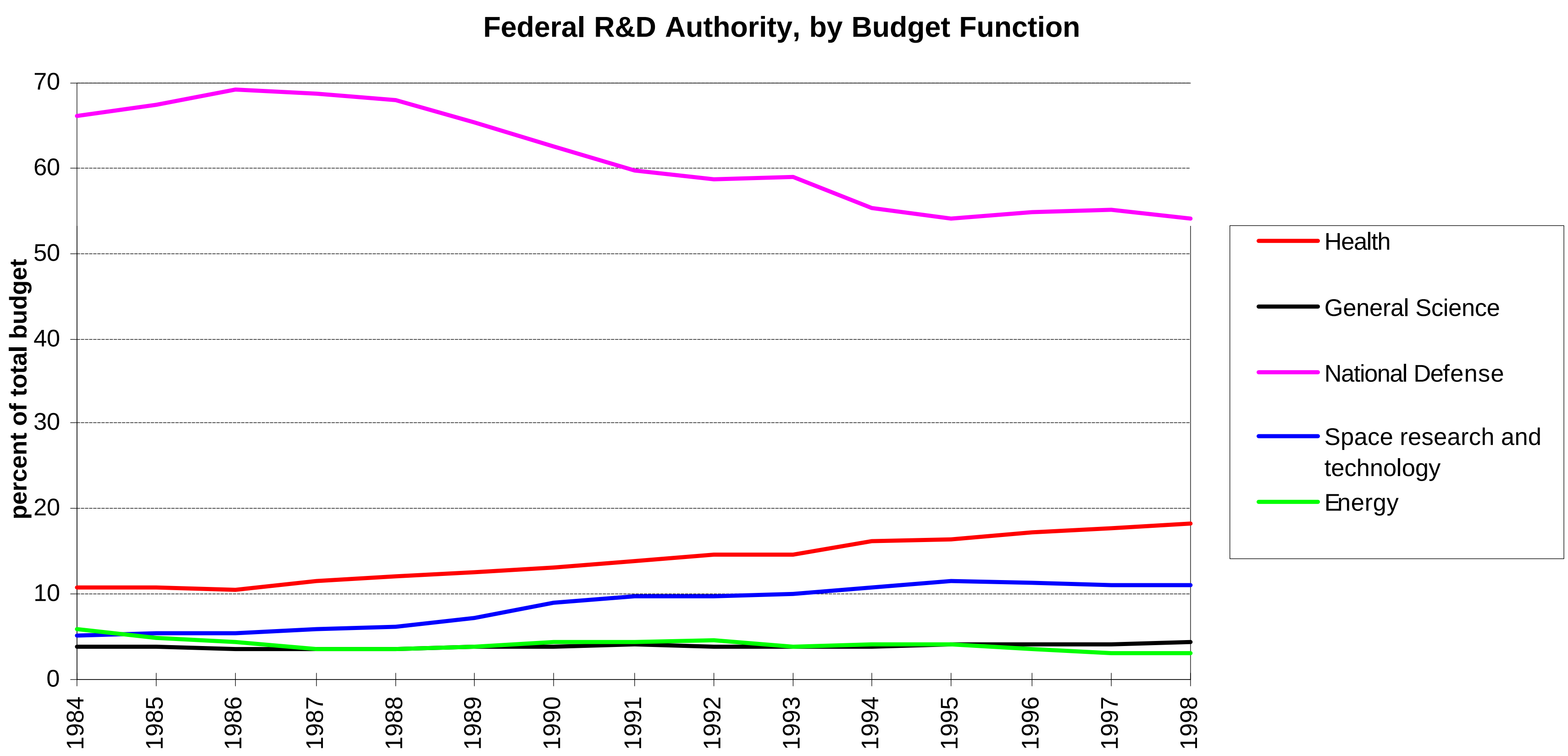
Key features of contemporary S&T enterprise:

- Multidisciplinary
- Partnerships
- IT intensive
- Rapid change

One result: Changing demands on the Nation's science and technology infrastructure

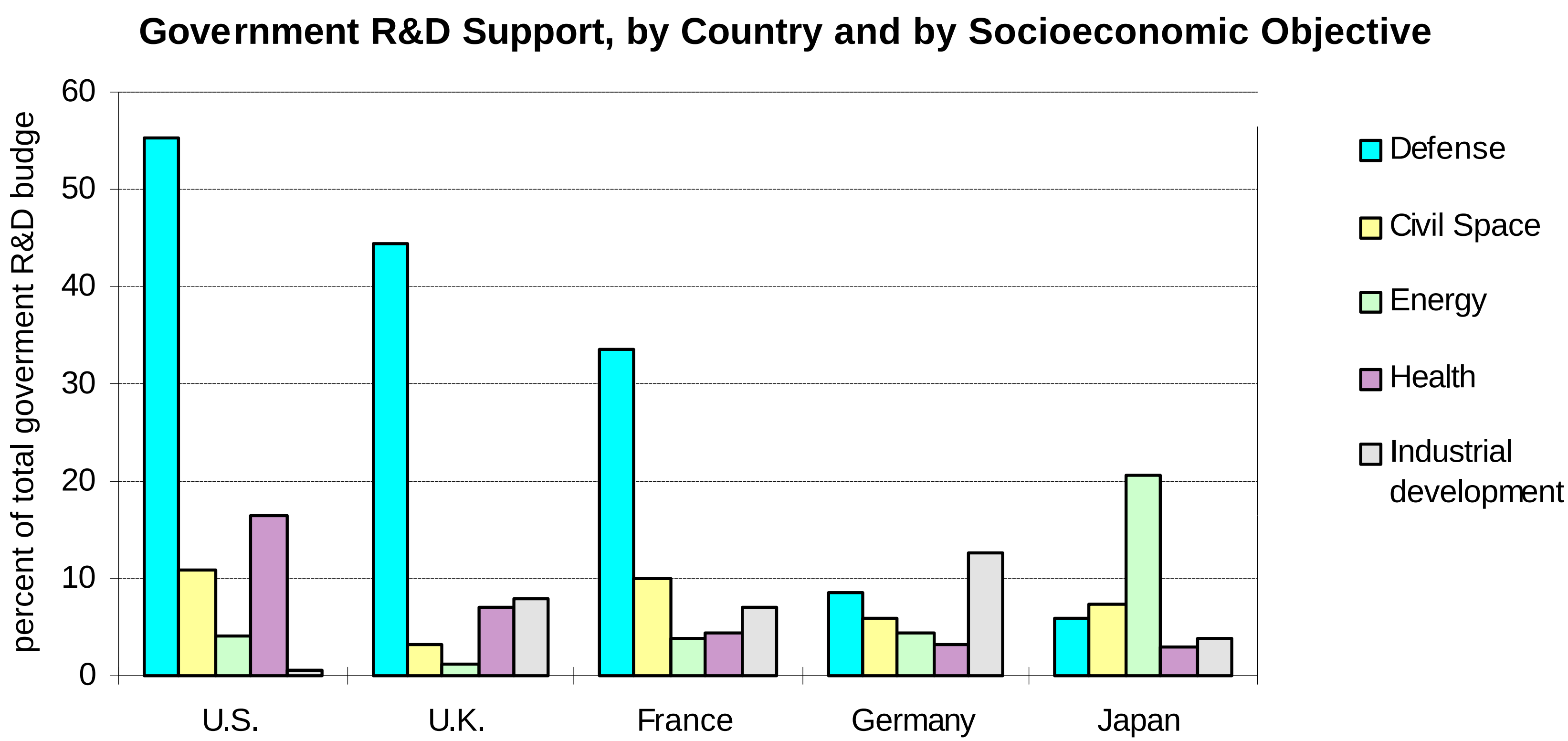
THE POLICY RESPONSE?

R&D budget trends: Decrease defense, increase health, most others held flat.



THE POLICY RESPONSE?

International comparisons. Distribution of U.S. Federal R&D spending is unlike any other advanced industrial country.



WHAT IS THE "RIGHT" LEVEL OF INVESTMENT?

No answer, in the abstract

Focus on the process: collaborate to identify, develop, and disseminate high-leverage technologies and services that the market cannot supply independently

For example: Guidelines for NIST Measurement and Standards Laboratories:

1. Assess industry needs
2. Assess corresponding NIST competencies
3. Benchmark to best in world
4. Evaluate performance

NIST APPROACH WORKS

Example: **Single-Crystal Critical Dimension Reference Materials for Next Generation Lithography**

1. SIA Roadmap: Need metrology advances to calibrate microchip measuring tools; 100 nanometers by 2006

2. NIST collaboration with Sandia produces single-crystal silicon measurement artifact that allows calibration of different measurement tools to assess features at 100 nanometers

3. Expect development of traceable-to-NIST SRM. Will support future manufacture of faster, more powerful microchips

IMPLICATIONS FOR TECHNOLOGY POLICY?

Need: Consensus on underlying principles and policy rationale for allocating scarce resources to areas with the greatest potential returns to the economy and society

A starting point? Six principles proposed by Branscomb and Keller:

1. Encourage private innovation
2. Emphasize basic technology research
3. Facilitate access to new and old technologies
4. Use all policy tools, not just R&D
5. Leverage globalization of innovation
6. Improve government effectiveness in policy development